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THE VALUE OF OUTRAGEOUS GEOLOGICAL HYPOTHESES[1]

MEETINGS of geological societies in these modern days are often somewhat prosaic as compared to those of an earlier time when the limits as well as the methods of geological speculation were less defined than now, and when contradictory differences of opinion were commonly expressed even with regard to fundamental ideas concerning the conditions and processes of earth history. That was a time when the scientific imagination, not so much hampered as it is now by standardized principles, was accustomed to roam with little restraint over the unexplored fields of geological investigation; a time when the facts regarding the earth's crust had been gathered from a relatively small part of its surface, when a theory was thought to be established if it explained nothing more than the facts which it had been invented to explain, and when lively discussion as to the merits of rival theories too often degenerated into polemical diatribes between rival theorists.

In those earlier days, attendance at the meetings of Section E of the American Association for the Advancement of Science—the only meetings in which geologists from different parts of the country were then brought together—was likely to be rewarded by a vigorous, not to say vituperative dispute between Marsh and Cope, not merely as to the completed structures and systematic relationships of the fossil vertebrates that they were finding in the fresh-water Tertiary deposits of the west, but also as to mere priority in finding and naming the fossils; and so eager was each of those eminent worthies to secure his prior claim for a new find before the other came upon it that, according to stories then current, one or both of them sometimes, while still in the western field, resorted to the telegraphic announcement of a name for a newly discovered fossil to be published in the eastern newspapers. In the years, half a century ago, when I first attended the meetings of the Boston Society of Natural History, they were occasionally the scene of emphatic contradictions between T. Sterry Hunt and M. E. Wadsworth on matters petrographic, for that recondite branch of geological science was then just taking form among us. Hunt knew exactly how rocks ought, in accordance with his theoretical views of terrestrial chemistry, to be constituted; while

[1] An address delivered before the Leconte Club of the University of California at its annual meeting at Berkeley, February 21, 1925.

Wadsworth, in view of his observational study of thin sections, knew exactly how rocks are constituted; and each of these convinced positivists maintained his view with earnest vehemence.

It is as a result of many verbal battles then fought without asking or giving quarter that geology has come in these modern days to be a relatively well-restrained and orderly science. How much more carefully are facts scrutinized, and how much larger and safer is the inductive base of our generalizations now than formerly. How narrowly limited is the special field, either in subject or locality, upon which a member of the Geological Society of America now ventures to address his colleagues; so narrow that he often has it pretty much all to himself, and so thoroughly does he cover it that when his statement is completed there is little or nothing left for any one else to say. How much more rigorously logical is the guidance of the train of thought by which advance is made from the facts of observation to the conclusions of theory; and if by good fortune a hearer differs from a speaker as to the track along which the train of thought should be directed, how seldom does he intimate his difference of judgment in any but the most courteous manner! How utterly extinct is rudely polemical dissension; so extinct indeed that the younger geologists of to-day must be surprised to learn that it ever flourished. I wonder sometimes if those younger men do not find our meetings rather demure, not to say a trifle dull; and whether they would not enjoy a return to the livelier manners of earlier times.

Yes, our meetings are certainly prosaic to-day as compared to those of the earlier formative period when speculation was freer and when differences of opinion on major principles were almost the rule rather than the exception. Our younger members may perhaps experience a feeling of disappointment, or even of discouragement at the unanimity with which the conclusions of an elder are received by a geological audience; for it must dampen the enthusiasm of beginners if they gain the impression that all the larger generalizations of our science have been established, thus leaving for them to discover only items of localized fact. And a like feeling of discouragement must often be shared by the chairman of a meeting when, after his encouraging invitation, "This interesting paper is now open for discussion," only silence follows. Are we not in danger of reaching a stage of theoretical stagnation, similar to that of physics a generation ago, when its whole realm appeared to have been explored? We shall be indeed fortunate if geology is so marvelously enlarged in the next thirty years as physics has been in the last thirty. But to make such progress, violence must be done to many of our accepted principles; and it is here that the value of outrageous hypotheses, of which I wish to speak, appears. For inasmuch as the great advances of physics in recent years and as the great advances of geology in the past have been made by outraging in one way or another a body of preconceived opinions, we may be pretty sure that the advances yet to be made in geology will be at first regarded as outrages upon the accumulated convictions of to-day, which we are too prone to regard as geologically sacred.

It was outrageous, two centuries ago, to interpret fossils as records of ancient life; for that interpretation did violence to the view then accepted as to the manner in which the earth had been formed and as to the date at which life had come to exist upon it. It was outrageous, little more than a century ago, to discover fossils of marine organisms in the disordered strata of lofty mountains high above sea level; for that discovery did violence to the ideas then obtaining as to the stability of the earth's crust. And it was equally outrageous, half a century ago, to be told that after mountains had been lifted up, they might in time be worn down to lowlands again, for that idea did violence to the views that had then come to be held regarding the instability of the earth's crust. It was an outrage upon the tacitly accepted principles of geological climatology, based on the postulate of a cooling earth, that there already should have been a glacial period in the past; and for that matter, the form in which the glacial theory was first promulgated was truly enough outrageous; nevertheless it now, in a much modified form, holds good as a standardized geological verity.

It was altogether outrageous to think that man had long been an inhabitant of the earth, instead of looking upon him as a new comer; and it was equally outrageous to discover that the sequence of fossils preserved in successive stratified formations indicated such a progression of life as would result from the evolution of later forms from earlier forms, instead of simply an arbitrary succession of independent creations. It is still rather outrageous to think that the earth has long been and possibly is still heating itself up by the slow compression of an originally uncompacted interior under the weight of a heavy exterior, instead of thinking that it has long been and still is cooling by the slow loss of a great original store of heat. And in view of the many evidences of crowding in the outer crust, it may be thought wantonly outrageous to look upon the earth as possessing an expanding interior which, like the caged starling, "wants to get out." Yet I believe it the part of wisdom to view even that outrage, as well as the Wegener outrage of wandering continents and the Joly outrage of periodical subcrustal heating-up and breaking out, calmly, as if they were all possibilities; and it may

also come to be the part of wisdom to ask ourselves in what way and how far our present conception of the earth must be modified in order to transform such outraging possibilities into reasonable actualities; for that is precisely the way in which the above-listed outrages and many others have gained an established place in our science. Of course, if we do not approve of the necessary modifications we may reject them, and with them the outrages that they countenance.

Let it be noted in passing that the omission of the original L from the leading word of the preceding paragraph unfortunately results in its being pronounced as if it were derived from "out" and "rage"; its true meaning would be better indicated if its form were ultrageous, as it might well have been had not the L been lost on the way from Latin through French into English; for with the L preserved, the T and R would be joined in the second syllable and properly separated from the first. A word of opposite meaning would then be, not in-rageous, but in-trageous; and our language would be much more symmetrically developed if that and many similar opposites were added to it. However, if we are not allowed to say ultrageous, we might—or at least those of us who pronounce the French-English word, "route," like the English word "root" might—say oo-trageous, and thus reasonably avoid the implication of an erroneous popular etymology. But this is an irrelevant digression.

All that was necessary to make the outrageous occurrence of fossils reasonable and believable was to remodel our conception of the earth from that of a recently-and-ready-made planet into that of a very ancient and slowly changing planet, on which life had existed for ages and ages, always under the influence of environing conditions and in the presence of slow-acting processes very much like those of to-day; and when the ideal counterpart of the actual earth was once conceived in this fashion, the earth was still found to be just as comfortable a planet to live on as it had been in association with the earlier concept of a ready-made earth. All that was needed to explain the occurrence of marine fossils in the disordered strata of mountain tops was to replace the concept of an immovable earth's crust by that of a deformable crust; and although the rate of deformation was at first thought to have been violently rapid, the need of such hurry was later seen to be no need at all, but only a fancy; and thereafter the deformation was conceived to be a slow process. And so it has been with one of these outrages after another: their accommodation is easily accomplished by merely replacing one concept of the earth, under which they are unacceptable, by another under which they are acceptable; and the replacement once made, we are just as happy as we were before. To be sure, the process of replacement may be mentally uncomfortable, even distressing, while it is going on; but the moral of that is that we must not allow our concepts of the earth, in so far as they transcend the reach of observation, to root themselves so deeply and so firmly in our minds that the process of uprooting them causes mental discomfort; and one of the best aids toward the realization of this moral may be found in frequently making explicit announcement of all the unproved postulates on which our favorite concepts are based; for then we shall not be so likely to forget that they are all preceded by a great big IF.

We shall be aided in following this counsel if we strive to recognize how far most of our concepts of the earth really do transcend the short reach of observation. It is usual for a field observer to record that he has seen, for example, a ridge of sandstone; yet all that he has actually seen is a series of small and disconnected sandstone outcrops, perhaps not occupying more than a twentieth or a hundredth of the ridge surface; and the composition of the rest of the surface and of all the interior of the ridge is only a matter of inference; truly, a good and justifiable inference, but not the less an inference for being good and justifiable. Similarly, it is customary for a field geologist to record the presence of a fault when he detects the repetition of a given sequence of strata, and indeed to believe in the displacement that the term, fault, implies, as if it as well as the recurrence of the sequence of strata were a fact of observation; yet not only are the underground extensions of the strata and their long-past displacement merely matters of inference, but even the fault-fracture itself is usually inferred instead of being seen; or if seen at all, it is seen only in small linear extent, thus leaving all the rest of its superficial trace as well as all of its surface, either lost in the air or buried underground, to the imagination. In thus making distinction between the few facts of actual observation and their large extension in a superstructure of inference, it is not intended to impugn for a moment the validity of well-reasoned superstructures, but only to emphasize the inevitable disproportion that must exist between them and their observed basis; and thus to make clearer the enormously speculative nature of geological science. For let it be noted that, in the case of a fault, we have to do with a double inference; first, the inference as to underground structures from surface outcrops; second, the inference of displacement because of the repetition of the inferred underground structures. Nevertheless, we believe that faults actually exist.

The very foundation of our science is only an inference; for the whole of it rests on the unprovable assumption that, all through the inferred lapse of time which the inferred performance of inferred geo-

logical processes involves, they have been going on in a manner consistent with the laws of nature as we know them now. We seldom realize the magnitude of that assumption. A philosopher of the would-be absolute school once said to me, in effect: "You geologists have an easy way of solving difficult questions: you account for the structures of the earth's crust by assuming that time and processes have been going on for millions and millions of years in the past as they go on to-day; but how do you know that time did not begin only a few hundred thousand years ago after the earth had been suddenly created in imitation of what it would have been if it had been slowly constructed in the manner that you assume?" The answer is as easy as the question: We do not *know;* we merely make a pragmatic choice between the concept of such an imitative creation which seems to us absurd, and a long and orderly evolution which seems to us reasonable. We might, to be sure, were we disposed to be disputatious, turn upon the would-be absolutist and ask him what he is going to do about it; but we have better use for our time than that.

The more clearly the immensely speculative nature of geological science is recognized, the easier it becomes to remodel our concepts of any inferred terrestrial conditions and processes in order to make outrages upon them not outrageous. The more definitely it is understood that the concept of a shrinking earth is based upon certain anterior concepts as to the status of its unobservable interior, the more readily can we entertain the concept of an expanding earth, based upon certain other concepts as to the status of its interior; and it is that particular outrage upon our standardized beliefs that I propose we should contemplate, calmly if possible, and patiently at any rate. To encourage our patience, let me recall another outrageous idea of recent introduction, which in itself is only a sort of reaction from an outrage of somewhat earlier invention and a return toward a more primitive view; namely, the recent idea that those topographical features which we call mountains owe their leading feature, namely, their height, not as has been until lately supposed to a vertical movement of escape from the horizontal thrust by which their rocks have been crowded together, but to an uplifting force which acted long after the rocks were crowded together, and in which, as was thought when the view of a mobile earth crust was first promulgated, no component of horizontal thrusting is necessarily involved. A chief difference between that primitive view and its revival in the recent outrage is that the first view took little account of erosion and implied that each individual ridge and peak was the result of an individual or localized uplift; while the second view takes great account of erosion, not only in ascribing the present intermont valleys to the long and slow action of that patient process during and after recent uplift, but still more in ascribing the destruction of the surface inequalities, that must have been earlier produced when horizontal thrusting forces crowded the mountain rocks together, to a vastly longer action of erosion before the recent uplift of the worn-down mass was begun; for where in the whole world can we find mountains that to-day owe their height to an upward escape from horizontal thrusting; in other words, where in the world can we find any existing mountains that are still in the cycle of erosion which was introduced by an upward escape from the horizontal thrusting that deformed their rocks, and not in a later cycle of erosion which was introduced by uplift alone after the inequality of surface form due to earlier thrusting had been greatly reduced, if not practically obliterated!

The conventional phrase, horizontal compression, has been avoided in the preceding paragraph and the alternative phrase, horizontal thrusting, has been used in its stead, in order to prepare the way for the rather mild idea that the same terrestrial forces which produce great overthrusts may also, if somewhat differently applied, produce rock folds, slaty cleavage, and various other phenomena ordinarily explained under the earlier phrase; and thus to prepare the further way for the altogether outrageous idea that overthrusts do not result from the effort of the outer crust to adjust itself to a cooling and shrinking interior, but from the effort of an in-any-way warming and expanding interior to rearrange the outer crust. Of course, this is "impossible"; that is, it is impossible in an earth of the kind that we ordinarily imagine the earth to be; but it is not at all impossible in an earth of the kind in which it would be possible. Our task therefore is to try to discover, as judicially and as complacently as we may, what sort of an earth that sort of an earth would be; and then to entertain the concept of that sort of an earth as hospitably as we can and to examine the behavior of such an earth at our leisure.

If an earth with an expanding interior had nothing more to do than to stretch its crust, there would be little trouble in our endeavor; but the concept before us compels the expanding earth to do various other things also; and especially to produce great crustal overthrusts, the cross-country advance of which is measured in tens or twenties of miles. Hence the outward radial push of the expanding interior must somehow be turned into an almost tangential thrust; and how that is to be done it is difficult to imagine. However, there is no reason for immediate discouragement on that account; it is very natural that our imagination to-day should fall short of conceiving all the possible behaviors of a warming and expanding

earth, because we are not practised in imagining—that is, in making an image of—that sort of an earth, although a good beginning in that direction has been made in such an essay as that by Boucher on "The pattern of the earth's mobile belts."[2] But we surely have yet much to learn as to what may be all the various reactions of an expanding earth-interior on the shell that encloses it, even though many possible reactions may be now conceived.

For example, let the enclosing shell be defined as that part of the whole sphere which is exterior to the depth at which the next inner shell is warming more rapidly than any other. If that depth be great, the chief thrust of the expanding interior will be exerted on a thick shell; if small, on a thin shell; and the effects of interior expansion visible on the surface will surely be different in the two cases. It seems conceivable that the total thrust of expansion may, in so far as it produces batholithic movement, be slowly concentrated at the weakest part of the shell, and there permit the interior movement to be locally increased by the conversion of cubic expansion into linear expansion or intrusion; this being the converse of the process by which an unduly heavy and therefore isostatically subsiding part of the crust may slowly distribute its local movement through the whole of the interior and there produce a diminished spherical extension, as Lawson has suggested. It seems also conceivable that the movement of a localized batholithic introduction may find advantage in making an outward escape from compelling interior pressures, by changing the direction of its ascent from vertical to oblique, and thus diminishing the rate at which it has to raise the overhead crust. Whether an obliquely ascending mass of this kind could eventually, as it approaches the surface, drive along a slice of crust ahead of it and thus produce what we call on overthrust, is evidently problematical; but if an overthrust could be produced in that way it would be gratifying in certain respects.

If an obliquely ascending batholithic intrusion works its way through a heavy shell toward the surface and there drives ahead of it a crustal slice which we recognize as an overthrust, the oblique emergence of such an overthrust slice will cause an underdrag of the covering rocks in the rear of thrusting advance, and thus displace them with more or less extensional jostling so that they will cover a greater breadth of surface than that which they occupied before being underdragged. Surely the need of some such underdragging ought to have been recognized long ago when the prevalence of so-called normal faults which indicate superficial extension, over other faults which indicate compression, was inductively established; and the need is still greater to-day when great faults, such as those of the Basin Ranges, have been found to dip at moderate angles, such as 50° or 40° to the downthrow; for such was the conclusion reached by Gilbert in his latest season of field work in the Great Basin a little over ten years ago.[3] It is true that some geologists maintain the possibility of producing so-called normal faults as an indirect effect of horizontal compressional forces; but even if so contradictory an effect may thus be possibly produced, it by no means follows that such faults can not also be produced much more directly by extensional forces; and the possible cause and working of extensional forces should therefore be investigated; for there is no generally accepted mechanism, like an underdrag, adequate for the strong extensional dislocation of crustal blocks with diverse displacements, to be found in the usual schemes of dynamical geology; and in the lack of such a mechanism, any process, even a fantastic process, that will cause a strong underdrag seems worthy of at least an hour's consideration.

But let no one imagine that I here put forth the idea of an expanding earth interior, with its imagined consequences of an obliquely out-and-over-thrust mass exerting an underdrag on the superficial crust in its rear, as an idea to be believed. I do not believe it myself, and am therefore doubly far from asking any one else to believe it. The idea is set forth simply as an outrage, to do violence to certain generally established views about the earth's behavior that perhaps do not deserve to be regarded as established; and it is set forth chiefly as a means of encouraging the contemplation of other possible behaviors; not, however, merely a brief contemplation followed by an off-hand verdict of "impossible" or "absurd," but a contemplation deliberate enough to

[2] *Journ. Geol.*, xxxii, 1924, 265–290.

[3] Since giving the address on which this article is based I have had opportunity of seeing several Basin Ranges, some in southeastern California, in company with that most competent of guides, Dr. L. F. Noble, of the U. S. Geological Survey, and some in Utah in the helpful company of Professors Schneider and Mathew, of the State University at Salt Lake City, and of Professor M. O. Hayes, of Brigham Young University at Provo; and the evidence then found for the occurrence of slanting fault surfaces seems to me indisputable, not only in the Basin Ranges themselves but also in the much longer bounding ranges of the Wasatch mountains on the east and the Sierra Nevada on the west. Far from the Range blocks being vertically uplifted without compression, as Gilbert first proposed in his report on the Wheeler Survey fifty years ago, still farther from their being the crowded blocks of a collapsed arch, as others have supposed, the Basin Range blocks seem to be the irregularly uplifted and diversely tilted blocks of a former lowland of erosion which has suffered a pronounced extension of its former east-west breadth, as I have briefly stated in the Proceedings of the National Academy of Sciences for July, 1925.

seek out just what conditions would make the outrage seem permissible and reasonable.

Let me close this address by explaining to this hospitable and sympathetic conclave why it seems peculiarly appropriate for me, an easterner, to set before the westerners here gathered the particular outrage with which I have detained them. It is because my contacts with the geology of the Pacific slope during the winter of 1924–25—very unconformable contacts, because of my preconceptions—have been outraging the views that I have more or less unconsciously gained on the Atlantic slope as to the demure quietude of the later geological periods. In the east, the Miocene, Pliocene and Pleistocene have witnessed only leisurely processes of degradation, deposition and deformation, all of small relatively measure; but here on the Pacific slope those periods have been characterized by an extraordinary activity; deposits of enormous thickness have been laid down, and those deposits have been deformed and eroded on a scale that is really rather disconcerting. Is it not fair, therefore, that in return for the incredible stories that have been told me here as to what has happened lately in Californian geology, I should take a turn at telling some outrageously impossible stories myself? In any case, there stand the Basin Range fault blocks, just beyond the eastern skyline of California, displaced in such a manner as to extend over a greater breadth of country than that which they previously occupied; and if it is not possible to explain their extension by underdrag, as an indirect reaction of a passive exterior crust on an expanding earth interior, then we must ask by what other outrageous process it is proposed to explain them.

W. M. DAVIS

HARVARD UNIVERSITY

OPPORTUNITIES FOR RESEARCH AT THE OCEANOGRAPHICAL INSTITUTE OF MONACO

THE original plan of Prince Albert I was to establish at Monaco a museum especially devoted to the collections made by him in the course of his scientific cruises, pursued each year from 1885 until the outbreak of the war. Later this plan was enlarged and the museum as it now exists is devoted in a general manner to all phases of oceanography. As a point of interest to its tourists who throng its Riviera each year it is second only to the Casino of Monte Carlo. The number of visitors has increased considerably in recent years and is now approaching one hundred thousand annually.

In addition to its popular interest as a museum and aquarium, attention should be called to its importance as an institution for original research and for its publication of both biological and physical oceanographical investigations.

Unfortunately, since the death of Prince Albert in 1922 the resources and activities of the institution have been somewhat curtailed. The successor of Prince Albert, not having the same interest in science as his father and not caring to assume the expense of maintenance of his father's steam yacht, the Hirondelle II, promptly sold it to an American moving picture corporation. Consequently, further data and material for research obtained by annual cruises are no longer supplied to the institute. The amount already on hand is, however, very great and is sufficient for many years' work. In accordance with an arrangement made by the prince before his death the publication of the results of his cruises is to be completed without cost to the institute. The seventieth volume is now in press and it is estimated that a total of about one hundred will be required for the complete publication. The rapidity with which the remaining volumes are issued will depend of course upon the rate at which work can be pursued, but that they will eventually appear seems without question.

In a letter addressed by Prince Albert I to the minister of public instruction of France, dated April 25, 1906, the foundation of the Oceanographic Institute is described in the following words:

> Having consecrated my life to the study of the oceanographical sciences I have recognized their importance to many facts of human activity, and I am prompted to secure for them the place they deserve in the solicitude of the government as well as in the consideration of scientists.
>
> Many countries have already sent scientific expeditions to all the seas of the world and these furnish to oceanography a solid basis for its development, but France, in spite of the special interest which the science of the sea holds for her, has not shown it the same interest, as it has other branches of science. However, I have given at Paris during several years lectures attended each time by a more numerous and attentive audience, for which public powers, in the person of President Loubet and members of the government, have by their presence exhibited a certain interest.
>
> Accordingly, I have desired to fill a void by myself creating and establishing at Paris a center of oceanographical studies, closely connected with the laboratories and collections of the Oceanographical Museum of Monaco, where I have assembled for twenty years the results of my personal investigations and those of eminent collectors who have come to me from all countries of Europe.

In addition to the original four millions the prince left to the institute another million at the time of his death. The income derived from this foundation, together with that obtained from the admission fee of

seventy-five francs paid by each visitor to the museum, is divided between the institute at Paris and the museum at Monaco. The diminishing purchasing power of the franc makes it increasingly difficult to carry on the excellent work so well done on their part by the institute.

It is to be regretted that no part of the large profits derived from the Casino of Monte Carlo goes to the institute, and also that the present Prince of Monaco does not emulate the example of his father in contributing freely to its needs. Thus a period has been reached at which the rate of growth of this important institution has been temporarily diminished.

A detailed description of the museum at Monaco has been published by Dr. Charles Atwood Kofoid in a bulletin of the U. S. Bureau of Education (1910, No. 4, whole Number 440) entitled "The Biological Stations of Europe." Especial attention is given in this article to the facilities obtainable at the museum for research.

Although a fairly large number of students and scientists from various countries availed themselves of the hospitality and opportunities offered for weeks at Monaco before the war, there have been very few since that time. To those who may be interested it should be mentioned that the invitation to work at the museum still holds good and every possible aid will be furnished to competent investigators who may find it possible to come to Monaco. It is interesting to know that in addition to five well-equipped laboratories in which there are accommodations for from eight to ten visiting scientists, there are also four completely furnished lodging rooms located in the institute which are offered without charge to those who would prefer to be near their work. Excellent meals can easily be obtained in Monaco for less than one dollar per day. This should prove especially attractive to those of limited means who may desire to pursue studies in a European laboratory. It is evident that with the present rate of exchange and the special arrangements made by the steamship lines for the cheap transportation of students to Europe a sojourn of several months at Monaco might cost even less than a similar stay at a less well-equipped laboratory in the United States.

The collections of this museum embrace thousands of carefully preserved specimens for which accurate and detailed information in regard to their source is available. The museum operates a small steam yacht for collecting material for the aquaria, and by means of this vessel living specimens for research may be easily obtained. The museum possesses a well-equipped chemical laboratory in which studies of chemical nature may be pursued. The library is rich in publications pertaining to all branches of oceanography and is ample to permit all necessary searches of the literature.

The present staff consists of the director and some five scientists and fifteen mechanics, attendants and guards. It is unfortunate that the time of this staff is occupied for the most part with details of maintenance and editorial work in connection with the publications of the institute rather than with research. It is particularly for this reason that Dr. Richard would welcome scientists who desire to take advantage of the facilities offered by his institution. Any one who may be interested in working at the Oceanographical Museum of Monaco should write to M. le Dr. Jules Richard, Musée Oceanographique, Monaco (Principauté). They should state the problem which it is desired to pursue and the particular material or apparatus required.

D. ATHERTON SEIDELL

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PARIS

SCIENTIFIC EVENTS

AWARD OF FELLOWSHIPS BY THE CHARLES A. COFFIN FOUNDATION

FIVE persons—four graduate students and one still an undergraduate—have been awarded fellowships for the year 1926–1927, by the Charles A. Coffin Foundation. These fellowships, awarded for one year, will enable the recipients to undertake research work at institutions of their own choosing. In addition to awarding the five new fellowships, the committee granted one renewal, and appointed one alternate.

The Charles A. Coffin Foundation, by which these fellowships were granted, was established in 1922 in honor of the first president and chairman of the board of directors of the General Electric Company. The object of these fellowships is to give financial assistance to a carefully chosen group of research men who would be unable to carry on their work without financial assistance. A sum of $5,000 a year is devoted to this purpose.

The committee by which the awards are made is composed of three members, not connected with the General Electric Company. The three making this year's awards were: Dr. Michael I. Pupin, representing the American Institute of Electrical Engineers; Dr. George B. Pegram, representing the Society for the Promotion of Engineering Education; and Gano Dunn, representing the National Academy of Sciences.

The awards are as follows: Hubert N. Alyea, for research work at Yale and Princeton on the inhibition of chemical reactions, studied photochemically and thermally. Bernard D. Holbrook, for investigating some phase (not yet determined) of the general problem of the reactions between radiant energy and matter, as investigated by the cloud-expansion chamber. Thomas J. Killian, for work in thermionic currents from absorbed films and conduction

in gases and vapors, to be pursued at Princeton. Lloyd P. Smith will study at Princeton during the coming year, and has taken the broad field of ionization as his subject. James E. Taylor, assistant professor at Wittenberg College, will engage in research work at Ohio State University, and will attempt a partial resolution of the isotopes of lead. Harold N. Rowe, who has for the past year been working at the University of Chicago under this foundation, has been granted a continuation of his fellowship for another year. During the forthcoming year he will engage in a test of the quantum theory of X-radiation. Warren F. Busse has been appointed an alternate. Mr. Busse is at present a research assistant at the University of Wisconsin, and proposes to study the relation of the chemical effect produced by the cathode rays outside the tube to the ionization produced.

GIFTS TO THE CASE SCHOOL OF APPLIED SCIENCE

DR. CHARLES S. HOWE, president of the Case School of Applied Science, has announced details of the progress of the campaign to raise funds for a new mechanical building and for additional endowment for the school.

An original gift of $500,000 was made on condition that the alumni raise $300,000, which with another gift of $200,000 would make a grand total of $1,000,000. Half of this amount was to go to the building of a new mechanical building and the other half for endowment. The campaign opened April 9 and ended April 16. Case School of Applied Science has roughly twenty-three hundred alumni. To date fifteen hundred and five subscriptions from the alumni, which means that more than sixty per cent. have already subscribed, have been received—subscriptions are still coming in. Instead of raising $300,000 the alumni have raised to date $404,000.

The original gift of $500,000 was given by Charles W. Bingham and when his name was announced an additional gift of $500,000 from his son, Charles W. Bingham, II, was also announced. The grand total to date therefore is approximately $1,625,000. The school will proceed immediately with the erection of the new mechanical building and undertake some other projects of progress which this gift has made possible.

THE NEW SOLAR OBSERVATORY IN SOUTHWEST AFRICA

WITHIN a few months the Smithsonian Institution expects, for the first time in history, to receive daily reports on solar radiation from the Eastern Hemisphere as a result of the establishment of a new solar observatory in Southwest Africa by the National Geographic Society's expedition headed by Dr. Charles G. Abbot, the solar expert of the Smithsonian Institution, who has just returned to Washington.

Construction on this new sun observation post, which is to operate in conjunction with other solar observatories in taking daily measurements of the solar constant, in an attempt to obtain data for long-range weather forecasting, has begun on the arid mountain of Brukkaros, in the center of a Hottentot reservation, with the assistance of the Public Works Department of the government of Southwest Africa.

The observatory and living quarters for the scientists are being built in natural caves, enlarged and improved, to obviate heating in winter and obtain cool rooms in summer. A reservoir of nearly 3,000 gallons capacity is being built to catch the infrequent rains in that part of Africa.

The two American scientific men who will be stationed on Brukkaros will have no easy access to their observatory. The nearest spot to which they will be able to take their supply automobile will be an hour's walk from the mountain.

The outstanding merit of Brukkaros as an observatory site is the clearness of the atmosphere. The place is seven miles north of Berseba, a Hottentot village with a white population of two persons.

Daily communication of solar radiation values probably will be by radio signals to Berseba, whence they will be relayed to Keetmanshoop and cabled to the Smithsonian Institution at Washington.

THE MILLS COLLEGE MEETING OF THE PACIFIC DIVISION, AMERICAN ASSOCIATION

THE tenth annual meeting of the Pacific Division of the American Association for the Advancement of Science will be held June 16 to 19, 1926, at Mills College, California. In accepting the invitation of Mills College to hold the 1926 meeting there the executive committee have been governed by the fact of its central location with respect to the large membership in the San Francisco Bay region and by its desire to recognize the outstanding character of Mills College, which has achieved notable importance on the Pacific Coast and now ranks among the best institutions of its class in the country.

Ample accommodations are assured and in the delightful surroundings of the college guests will find much of interest for the employment of their time between sessions. Mills College is within the city limits of Oakland about five miles from the city hall. It may be reached from San Francisco in one hour and a quarter and from Berkeley and the University of California in a half hour.

A special committee has been appointed to provide entertainment for visiting ladies who may not

wish to give all their time to attendance at the scientific meetings. The splendid Art Gallery recently established will be opened, musical programs will be presented and other entertainment provided.

GENERAL SESSIONS

The general sessions will open at the luncheon hour on Wednesday, June 16, 1926, when the usual research conference will be held. The subject "What can the Colleges Contribute to Scientific Research?" will be discussed under the leadership of Professor Howard E. McMinn, department of botany, Mills College. Particularly it is proposed to consider methods of inciting interest in research work among undergraduates and providing special training with this objective. Members are invited to participate in the discussion.

On Wednesday afternoon, June 16, in Lisser Hall, a symposium on "The Constitution of Matter" will be presented. The remarkable results of recent research into the nature and structure of the atom will be given in somewhat popular form by specialists in their respective topics. The symposium is arranged as follows:

The Elements and their Composition: DR. T. R. HOGNESS, of the department of chemistry at the University of California.

Atomic and Molecular Structure: DR. HERTHA SPONER, of the physical institute of the University of Göttingen, Germany.

The Nature of the Atom as Explaining and as Exhibited by the Lines in the Stellar and Solar Spectra: DR. H. H. PLASKETT, of the Dominion Astrophysical Observatory, British Columbia.

The Structure of Matter as Elucidated by X-Rays: MAURICE L. HUGGINS, of the department of chemistry at Stanford University.

On Wednesday evening at eight o'clock in Lisser Hall the address of the President of the Pacific Division will be given. Following an address of welcome by the president of Mills College, Dr. Aurelia Henry Reinhardt, and a response by Dr. J. H. Hildebrand, chairman of the executive committee, the retiring president of the Pacific Division, Dr. Robert G. Aitken, will speak on "The Solar System; Some Unsolved Problems." The address will be illustrated with stereopticon.

Immediately following the address of the president adjournment will be taken to Alumnae Hall where a public reception will be held.

The annual dinner has been arranged for Thursday evening, June 17, at 6:30, for all members and visiting guests. After dining the members will adjourn to Lisser Hall, where Dr. L. O. Howard, chief of the U. S. Bureau of Entomology, will deliver an address on "Insects and Human Progress."

The general sessions will close Friday evening, June 18, with an address by Dr. W. F. Durand, president of the American Society of Mechanical Engineers, on the subject of "Science and Civilization."

Fifteen affiliated societies have signified their intention of holding meetings at Mills College under the auspices of the Pacific Division, as follows:

American Association of Economic Entomologists, Pacific Slope Branch
American Meteorological Society
American Physical Society
American Phytopathological Society, Pacific Division
Astronomical Society of the Pacific
Botanical Society of America, Physiological Section
Cooper Ornithological Club
The Ecological Society of America
Pacific Coast Entomological Society
San Francisco Aquarium Society
Seismological Society of America
Society of American Foresters: California Section, North Pacific Section
Society of Experimental Biology and Medicine, Pacific Coast Branch
Western Psychological Association
Western Society of Naturalists
Western Society of Soil Science

SCIENTIFIC NOTES AND NEWS

AT the dinner of the National Academy of Sciences at Washington on April 27 the Agassiz Medal was presented to Dr. Vilhelm Bjerknes, of Bergen, Norway, for outstanding contributions to oceanography, and the Henry Draper Medal to Professor Harlow Shapley, of Harvard University, for distinguished contributions to astrophysics. Presentation of the Agassiz Medal was made by Dr. T. Wayland Vaughan and was received for Dr. Bjerknes by the minister of Norway. The Henry Draper Medal was presented by Dr. Henry Norris Russell and, in Dr. Shapley's absence in Europe as exchange professor to Belgium, was received by Professor Frank Schlesinger.

THE National Academy of Sciences has elected the following foreign associates: Jacques Hadamard, professor of analytical and cosmic mechanics at the École Polytechnique, Paris, and professor of mathematics at the Sorbonne; Richard Willstätter, formerly professor of chemistry at the University of Munich; Sir Frank Watson Dyson, director of the Royal Observatory of Great Britain; Max Planck, director of the Institute of Theoretical Physics at the University of Berlin. No members were elected this year. Dr. Robert A. Millikan, of the California Institute of Technology, Pasa-

dena, Calif., was reelected foreign secretary for a term of four years. Dr. Robert A. Harper, of Columbia University, and Dr. Oswald Veblen, of Princeton University, were elected to the council of the academy for the three years ending with the annual meeting in April, 1929.

AT the recent meeting of the American Philosophical Society in Philadelphia the following members were elected: Irving W. Bailey, James M. Beck, Gilbert Ames Bliss, John Cadwalader, Jr., Roland Burrage Dixon, William Charles Lawson Eglin, William P. Gest, Charles E. Hughes, Charles Kenneth Leith, Ralph Modjeski, Oscar Riddle, John M. Scott, William F. G. Swann, Henry Osborn Taylor and Alfred North Whitehead.

PROFESSOR A. A. MICHELSON, of the University of Chicago, will spend five months this summer at the Mount Wilson Observatory, Pasadena, Calif., where he will continue his measurement of the velocity of light.

DR. ERNEST CLAYTON ANDREWS, government geologist of New South Wales, will give the Silliman lectures at Yale University in 1926–27 on the subject of "The Geology of the Pacific Area."

DR. KONRAD E. BIRKHAUGH, of the University of Rochester, has received a $500 award established by the Women's Educational and Industrial Union for his work on the treatment of erysipelas.

THE Mining and Metallurgical Society of America has awarded its gold medal for 1925 to Daniel C. Jackling, of San Francisco.

THE Franklin Institute has awarded its Louis Edward Levy Medal to Dr. E. G. Coker, professor of civil and mechanical engineering at University College, London, for his paper on "Photo-Elasticity," published in the *Journal* of the institute.

DR. G. KINGSLEY NOBLE, curator of amphibians and reptiles in the American Museum of Natural History, has been made a corresponding member of the Zoological Society of London.

F. W. LANCHESTER has been awarded the gold medal of the Royal Aeronautical Society and elected an honorary member of the society in recognition of his pioneer work in aviation.

DRS. JOSÉ CARRACIDO, professor of biological chemistry at Madrid, and H. G. Greenish, professor of pharmacy, London, were recently elected corresponding members of the French Academy of Medicine.

A TESTIMONIAL dinner was tendered Dr. Albert P. Brubaker at the Adelphi Hotel on March 27 by the alumni of the Philadelphia College of Dental Surgery and the Dental Department of Temple University, in which Dr. Brubaker has been professor of physiology for more than twenty years.

IN honor of the recent election of Theodore J. Bradley, of Brookline, dean of the Massachusetts College of Pharmacy, to the presidency of the American Pharmaceutical Association, members of that organization tendered him a complimentary dinner on April 29. The principal speaker at the dinner was Eugene G. Everle, of Baltimore, editor of the *Pharmaceutical Journal*.

A TESTIMONIAL, signed by the leading representatives of astronomy and astrophysics in Great Britain, was presented to Sir Howard Grubb in recognition of his skill and long-continued labors in the production of large objectives for astronomical instruments.

PROFESSOR H. NAGAOKA, who has occupied the chair of physics at the Imperial Tokyo University for nearly thirty years, has been honored by a compilation of a volume of original papers by his friends and students. The volume was published in celebration of the twenty-fifth anniversary of his appointment but was delayed by the earthquake.

THE New York Academy of Sciences has appointed the following delegates to the International Congress of Plant Sciences to be held at Ithaca, N. Y., on August 16 to 23: Dr. N. L. Britton, Professor R. A. Harper and Professor H. M. Richards.

AT the annual meeting of the Anthropological Society of Washington, on April 20, the following officers were elected for the ensuing year: *President,* Mr. Neil M. Judd; *Vice-president,* Mr. David I. Bushnell, Jr.; *Secretary,* Dr. John M. Cooper; *Treasurer,* Mr. Henry B. Collins, Jr. Mr. Herbert Krieger, Dr. Charles L. B. Anderson, Mr. J. N. B. Hewitt, Dr. Daniel Folkmar and Mr. B. H. Swales were elected councilors.

ACCORDING to an Associated Press dispatch, A. L. Pickens, professor of biology at Furman University, a Baptist institution, has resigned as a result of a conflict of views on evolution with the trustees.

ARTHUR CLARK TERRILL, formerly professor of mining engineering at Pei-Yang University, Tientsin, China, has been appointed petroleum engineer, State Mining Bureau, Los Angeles.

G. M. RAPP, assistant engineer with the Delaware River Bridge Commission, has resigned to become assistant engineer with the Port of New York Authority.

EARL S. HASKELL, of the department of middle American research at Tulane University and formerly with the U. S. Department of Agriculture, has been appointed director general of agriculture for Persia, and is sailing from New York this week.

PROFESSOR GEORGE D. SHEPARDSON, head of the department of electrical engineering at the University of Minnesota, is spending his sabbatical year on a tour around the world.

PROFESSOR YOSHIJI YOSHII, professor of plant physiology, Biological Institute, Tohoku Imperial University, Sendai, Japan, is visiting the United States.

DR. SAMUEL J. BARNETT, research associate of the Carnegie Institution of Washington, is lecturing on physics during the second semester of this year at the University of California, Southern Branch, at Los Angeles.

PROFESSOR MICHAEL I. PUPIN, professor of electromechanics at Columbia University, will be the principal speaker at the banquet of the Radio Club of America, which is to be held on May 13, at the Hotel McAlpin, New York.

DR. LIBERTY HYDE BAILEY, president of the American Association for the Advancement of Science, is to deliver the baccalaureate address at the fiftieth annual commencement of Texas Agricultural and Mechanical College, on June 2.

DR. FRANK BALDWIN JEWETT, vice-president of the American Telegraph and Telephone Company, and president of the Bell Telephone Laboratories, will give the commencement day address at Purdue University.

DR. JEROME ALEXANDER, consulting chemist and chemical engineer, of New York, will give an address on May 13, before a meeting of Phi Beta Kappa Alumni in New York. The subject of the address will be "Down to the Atom and within it."

SIR ARTHUR NEWSHOLME gave two De Lamar lectures in the School of Public Health and Hygiene of the Johns Hopkins University, on May 4 and 5, when he spoke on "William Farr, the Father of English Vital Statistics" and "The Growth of Social Insurance in England."

DR. KNUD FABER, professor of internal medicine, University of Copenhagen, recently gave an address at the Harvard Medical School, Boston, on "The Intestinal Origin of Pernicious Anemia."

AMONG the nine busts to be unveiled in the Hall of Fame at New York University on May 12 is one of Eli Whitney, inventor of the cotton gin.

Mechanical Engineering states that as a memorial to John Edson Sweet, founder of The American Society of Mechanical Engineers, first head of the College of Engineering at Cornell University, and inventor of the straight-line engine, friends of Cornell University are raising a fund to endow a professorship at the university to be known as the Sweet memorial professorship. The endowment plan happens to coincide to some extent with the Sesquicentennial Celebration in Philadelphia, in the fact that the straight-line engine invented by Professor Sweet was used at the 1876 Centennial to drive the first dynamo ever made in the United States. This dynamo was constructed at Cornell and is still in use in a Cornell laboratory. Professor Sweet died in 1916. More than half of the fund has already been subscribed by about one hundred men.

HERBERT FRANKLIN DAVISON, assistant professor of chemistry in Brown University, died on April 29, aged forty-five years.

DOUGLAS B. YOUNG, for nearly twenty-five years assistant state entomologist of New York, died on April 5, aged sixty-six years.

SIR TIMOTHY AUGUSTINE COGHLAN, of Australia, statistician and formerly president of the Australasian Association for the Advancement of Science, died on April 30, aged sixty-nine years.

PROFESSOR W. J. LEWIS, F.R.S., professor of mineralogy at the University of Cambridge, died on April 16 at the age of seventy-nine years.

PROFESSOR L. G. GOUY, of the University of Lyons, distinguished for his contributions to the theory of the propagation of spherical waves, the velocity of light and Brownian movements, died on January 27, aged seventy-two years.

DR. CARLO DE MARCHESETTI, honorary director of the Museum of Natural History and director of the botanic garden, Trieste, died on April 2.

PROFESSOR FRITZ RAUSENBERGER, known for his work in ballistics, died in Munich on April 30, aged fifty-eight years.

THE *Journal* of the American Medical Association reports the death of Dr. Levy, assistant professor of physiology, Turin. She was with a skiing party overwhelmed by an avalanche.

THE thirty-fourth annual meeting of the Society for the Promotion of Engineering Education will be held at the State University of Iowa from June 16 to 18.

SUMMER meetings of the American Mathematical Society will be held at the Ohio State University this year and at the University of Wisconsin in 1927.

A MEETING of the San Jacinto section of the Western Society of Naturalists was held on April 23 at Pomona College, California. At the scientific session fifteen papers were given and two others read by title. The president of the section, Dr. O. L. Sponsler, presided. In the evening about thirty members dined at

the Claremont Inn and later at the home of W. A. Hilton, secretary-treasurer, listened to a paper by Dr. R. C. Denison, of the department of philosophy of Pomona College, on "Philosophy and Science." The following two days a few members took a field trip to the region of Rock Creek Canyon, north of Claremont. The officers elected for the next year were: Gordon Surr, *president*, and Edmund Jaeger, of the Riverside Junior College, *secretary-treasurer*.

THE Sigma Xi Alumni Association of the University of Pittsburgh, the secretary of which is Dr. Richard Hamer, held a meeting on April 5 when papers were presented from the department of mathematics by M. M. Culver, F. A. Foraker, A. E. Staniland and K. D. Swartzel.

PUBLIC lectures will be given at the New York Botanical Garden during May and June on Saturday afternoons at 4:00 o'clock as follows: May 1, "Variation, Heredity and Environment in Relation to Evolution," Dr. A. F. Blakeslee; May 8, "The Bermuda Islands," Dr. Fred J. Seaver; May 15, "Tulips," Mr. Kenneth R. Boynton; May 22, "The Land of Cotton," Dr. Israel Weinstein; May 29, "Iris and its Culture," Dr. George M. Reed; June 5, "Floral and Scenic Features of Porto Rico," Dr. H. A. Gleason; June 12, "The Extinct Flora of New York City and Vicinity," Dr. Arthur Hollick; June 19, "Roses," Dr. Marshall A. Howe; June 26, "Our Friend John Burroughs," Dr. Clara Barrus.

AT the twenty-third annual meeting of Experimental Psychologists, held at the University of Pennsylvania from April 5 to 7, the following resolution was passed:

RESOLVED, That this meeting deplores the increasing practice of collecting administrative or supposedly scientific data by way of questionnaires; and

That the meeting deplores especially the practice under which graduate students undertake research by sending questionnaires to professional psychologists.

The resolution was sponsored by the following members: Edwin G. Boring, Harvard University; Samuel W. Fernberger, University of Pennsylvania; Herbert S. Langfeld, Princeton University; E. S. Robinson, University of Chicago; E. B. Titchener, Cornell University, and R. S. Woodworth, Columbia University.

THE Swedish parliament has rejected a proposal to make the Nobel prize fund tax-free. The proposal was made by members of all political parties, which considered it wrongful that the state should take a good deal of money donated for the international progress of civilization. The Swedish state, from the beginning of the fund, has had an income on this tax of 10,000,000 crowns and last year the tax, it is said, was higher than the prize sum given in that year.

WITH total assets of $199,031,338, consisting chiefly of gifts of John D. Rockefeller, the annual report of the Rockefeller Foundation for the year ending December 31, 1924, now issued, states that income during the year was $8,191,338 and expenditures were $7,288,822. The balance on hand was $7,607,187 as compared with $6,704,503 in 1923. The expenditures included $1,676,495 for checking hookworm, malaria and yellow fever; $405,876 for public health education; $1,146,297 in China, and $2,045,293 for medical education.

JOHN D. ROCKEFELLER, JR., has made an unconditional gift of $125,000 to the American Society for the Control of Cancer of New York, according to an announcement by Winthrop W. Aldrich, who is in charge of the campaign of the society for an endowment of $1,000,000. Mr. Rockefeller also made a gift of $10,000 to defray the expenses of a congress of the leading cancer specialists of this country and Europe at Lake Mohonk in September. A luncheon was to be held at the Lawyers' Club, 115 Broadway, on May 6, by the committee and others interested in the society's work. The speakers were Dr. Wood, Dr. James Ewing and Dr. Taylor.

AT a recent meeting of the British Empire Cancer Campaign, in London, the following grants were made: £1,695 to St. Bartholomew's Hospital, towards the maintenance of their new X-ray Cancer Research Department; £2,500 to the Cancer Hospital (Free), towards the upkeep of their Cancer Research Institute; £3,000 to the Middlesex Hospital, for cancer research purposes; £300 to Dr. Malcolm Donaldson, in connection with his investigations into certain inoperable cases of cancer; a further £250 to St. Mark's Hospital for cancer research purposes, making a total grant of £500 for the year; £300 to Professor Charles Walker, of the Liverpool University, to defray certain cancer research expenses; and £300 to Professor Wilkie, professor of surgery, Edinburgh University, for the purchase of apparatus and material for use in connection with cancer research. These grants, together with the provision for commitments entered into by the campaign, approximate to an expenditure of £85,000 to date. The grand council was informed that the first number of the publication, to be known as the *Cancer Review*, of the campaign would be issued during the month of May and would continue thereafter as a monthly publication.

THE family of Mr. Alexander M. White, of Brooklyn, has offered $100,000 to be added to the fund of $250,000 being raised to meet the condition of Mr. John D. Rockefeller, Jr.'s, gift of $250,000 for the endowment of the Brooklyn Botanic Garden. Mr. White is head of the citizens' committee of 260 members which is working to obtain the endowment.

THE department of botany of Rutgers University is the recipient of an herbarium collection of ten thousand dried plants, presented by Mr. E. D. Riley, of Absecon, N. J. This collection contains valuable material from the southern part of the state, and a considerable number of plants from Ohio and California as well. A part of the collection was exhibited by Mr. Riley at the Columbian Exposition. Founded by Dr. N. L. Britton, botanist of the *Geological Survey,* in the years of 1881–1890, the State Herbarium has been developed until it contains a considerable representation of the flora of the state.

UNIVERSITY AND EDUCATIONAL NOTES

FRIENDS of Professor William Berryman Scott, chairman of the department of geology at Princeton University, plan to raise $50,000 to establish a Scott research fund in paleontology, as part of the $2,000,000 fund which Princeton is endeavoring to raise for advanced teaching and scientific research.

AT the University of London, a university chair of bacteriology and immunology, tenable at the London School of Hygiene and Tropical Medicine, and a university chair of epidemiology and vital statistics, tenable at the London School of Hygiene and Tropical Medicine, have been instituted.

PROFESSOR ARNOLD BENNETT HALL, of the department of political science at the University of Wisconsin, has announced his acceptance of the presidency of the University of Oregon and will assume his duties in September.

IT is announced from the University of Wisconsin that Professor Arthur Sperry Pearse, of the department of zoology, has resigned to accept a research professorship in Duke University, Durham, S. C. He is now on a leave of absence, studying in the London School of Tropical Medicine.

DR. A. A. MOORE, professor of physiology at Rutgers University, has recently accepted the position of professor of zoology at the University of Oregon.

THE department of botany at the University of Texas has been reorganized to provide for the development of courses in bacteriology given by the department. The name has been changed to the department of botany and bacteriology. The staff in botany consists of Professors I. M. Lewis, F. McAllister, John T. Buchholz and Associate Professor B. C. Tharp; in bacteriology, Professor I. M. Lewis, Adjunct Professors E. E. Pittman and O. B. Williams.

THE recent announcement of changes in the department of mathematics at Princeton University should read as follows: Dr. J. W. Alexander has been made associate professor and Dr. Tracy Yerkes Thomas has been made assistant professor.

PROFESSOR L. E. BLACKMAN, formerly employed as research chemist at the University of Delaware, Agricultural Experiment Station, has been appointed to the headship of the chemistry department of Upper Iowa University, Fayette, Iowa.

RECENT promotions at Princeton University include the following: Associate professors, B. F. Howell, A. F. Budington, R. M. Field, in the department of geology; F. A. Heacock, department of engineering; assistant professor, Philip Kissam, department of engineering.

DR. V. A. TAN has been appointed to a professorship of mathematics at the University of the Philippines. He received the doctorate at the University of Chicago in June, 1925.

DISCUSSION AND CORRESPONDENCE

ANTAEUS, OR THE FUTURE OF GEOLOGY

IT may seem strange for a scientist to venture to offer a defense of the study of the classics in these days of uneducated scientific experts, and yet I can not help but feel that the older and now largely discredited training prepared one somewhat better for life, even the life of a well-rounded scientist, than the present technological preparation for a profession. I am not denying that the quintessence of culture can be gotten out of any science, but we are not all Huxleys, and one must ruefully admit that among us mediocre men who necessarily make up the bulk of the present day enlarged army of scientists, the full life is exceptional, and the cultural level is exceedingly low.

One never ceases to wonder at the important truths tucked away in Greek mythology, and among these there is none so full of meaning for every one as the legend of Antaeus, and it contains also a most serious and timely warning for geologists. To the man in the street its moral has been unconsciously voiced in the compelling phrase "Getting down to brass tacks."

Antaeus was a Libyan giant, the son of Poseidon and Gaea, and it could not be more appropriate than that the personification of geology should be the son of such a fitting union as the sea and the earth, and what could be nearer the mark of expressing the true ideal of a geologist? Antaeus compelled all strangers passing through the land to wrestle with him. When thrown, as he permitted himself to be, the strength which came to him from this contact with mother earth rendered him invincible, and he was thus enabled to build a temple with the skulls of his victims.

Some of the leaders in current geological thought are what Diener, in the Introduction to his admirable little book on Biostratigraphy, calls devotees of geoposie, geotheosophie, or transcendental geology, and it is for these that the story of Antaeus originated several thousands of years ago, although it contains a moral that all of us can reflect upon with profit.

Let me recall what finally happened to Antaeus. Heracles, discovering the apparently hidden source of his strength, lifted him up and held him away from the earth, and thus was able to crush him to death, and so he perished miserably.

According to their varying temperaments the wisdom of all of the ancients voices the same admonition for geologists. We find in the book of Job the phrase "Speak to the earth and it shall teach thee," and be it remembered that it is only in this way that a geologist may acquire wisdom—it is not obtained by floating above the clouds with Jupiter, nor by projecting oneself in imagination into the realm of his brother Pluto, and I believe that much that passes as science in current geological writings is not science at all, however pleasing it may sound.

The same thought is repeated for us in the words of the saintly flower of medieval monasticism, the abbot of Clairvaux, who says: "Trees and rocks will teach what thou canst not hear from a master." (Bernard, 1090–1153.) It behooves us then, if we are to add a chapel or a pinnacle, or even an additional column, arch or foundation stone to the Temple of Geology, to stop our ears to the lure of the sirens of speculation, and the imaginary spiritualistic voices of arm chair philosophy, and to hie ourselves to the seashore and the rocks.

Otherwise the fate of Antaeus is sure to overtake us, if it has not already done so.

EDWARD W. BERRY
THE JOHNS HOPKINS UNIVERSITY

UPPER PLEISTOCENE OCCURRENCE ALONG THE OAXACA COAST OF MEXICO

THE Oaxaca coast of Mexico is a series of alternating depressions and elevations. In one of the recently elevated areas there are exposed patches of Upper Pleistocene for a distance of some twenty-eight miles. In some places the formation is exposed along the shore and in others a mile and a half inland. It forms a low cliff with an extreme elevation, where observed, of fifty! At other points it is but a few feet high and in still others it is exposed only at low tide.

For the most part the formation is a soft gray or buff sandstone, though locally it is hard and flinty. In one of the exposures there is an abundant fauna that is remarkably preserved. Many of the extremely fragile shells are entirely intact, gastropods with protoconchs are common and in many cases the colors still persist. The preservation of the forms are, almost without exception, better than that of the shells living along the coast. This preservation and the absence of any appreciable cross-bedding are indicative of tranquil shore conditions, which strongly contrasts with the present-day wave-buffeted strand.

A majority of the forms are the same as those now living along the present beach; some are not known to be living and a few show slight though constant differences from their living descendants, suggesting that evolution has been operative since Pleistocene times among the invertebrates as well as among the vertebrates.

Another fact of interest is that among this fauna there are ten or more species that are reported only from Panama and further south. This indicates that the sea was somewhat warmer than at present, which is in accord with the northern migration along the west coast that is known to have occurred during Upper Pleistocene.

R. H. PALMER
STANFORD UNIVERSITY

CONSERVATION OF OUR NATIVE CHESTNUT

IN 1924 the writer published a note[1] concerning the survival of chestnut trees in Pennsylvania, on an area in which the trees were carefully measured for new growth and blighted wood. It was found that the new growth was eighteen times that killed in the same year. Other observers, as Clute,[2] Collins,[3] Gravatt,[4] Graves[5] and Hodson,[6] have noted immunity to some degree, or recovery of portions once blighted. The bark at the base has been demonstrated (Graves, *l. c.*) to be more resistant, apparently because of a larger tannin content.

In the past summer (1925) the same plot was resurveyed and the ratio of new to old growth was

[1] Kelley, A. P., 1924, "Chestnut Trees Surviving Blight," SCIENCE, n.s. 60: 292–293.

[2] Clute, W. N., 1924, "Resistant Chestnuts," *Am. Bot.*, 30: 168–169.

[3] Collins, J. F., 1920, "Note on Resistance of Chestnut to Blight," *Phytopath.*, 10: 368–371.

[4] Gravatt, G. F., 1926, "Scouting for Blight Resistant Chestnuts," *Amer. Nut Journ.*, 24: 8.

[5] Graves, A. H., 1926, "The Present Continued Development of Basal Shoots from Blighted Chestnut Trees," SCIENCE, n.s. 63: 164–165.

[6] Hodson, E. R., 1920, "Is American Chestnut Developing Immunity to the Blight?" *Journ. Forestry*, 18: 693–700.

found to be only three to one. Observations on other areas indicated that the general average for the region was closer to five to one. This lowering of the ratio may have been due in part to the unfavorable weather conditions which prevailed over the Middle Atlantic states during the growing season of 1925, but even a ratio of three to one is encouraging.

The older trees mentioned in the previous note have continued growth and they bore a copious crop of nuts last autumn. The nuts, however, were promptly consumed by squirrels and boys of the neighborhood, and branches of some of the trees were broken by stones and brickbats thrown against them. These trees and others similar to them (for they seem to be by no means rare) should now be carefully protected from injury and given opportunity to propagate the species.

ARTHUR PIERSON KELLEY

RUTGERS UNIVERSITY

SPECIAL CHARACTERS FOR THE TYPEWRITER

I WAS much interested in reading "Special Characters for the Typewriter" as set forth by Mr. Hulse in SCIENCE for March 26.

One company (the Remington) makes special keyboards, as the medical keyboard and the mathematical keyboard.

The medical keyboard appears to be fairly well suited to the physicians. But the mathematical keyboard is not so well suited to the mathematicians. It leaves off the useful characters \$, %, ¼, ½ and ¾, in order to put on some other mathematical signs.

I think that if a successful mathematical keyboard be made with a forty-two-typebar machine, it will have two shifts, instead of one, and 126 characters instead of 84. Then it could have exponents, as well as many other useful mathematical signs. Of course, such a machine would cost more, and it would be worth more.

I think the mathematical societies should investigate this problem, and tell the typewriter companies what should be done.

AD INFINITUM

THE UNIVERSITY OF WASHINGTON AND FISHERIES RESEARCH

ON page 91 of the January 22, 1926, number of SCIENCE appeared the following note about the University of Washington, which I would like to correct.

The University of Washington is to be an international center of the United States and Canadian fisheries research work on the Pacific Coast, according to announcement from Dean John N. Cobb, of the College of Fisheries. The International Fisheries Commission, composed of official state fisheries commissions of Pacific coast states, Alaska and British Columbia, together with the entire Canadian department of fisheries, will consolidate all work here. The university was selected especially because of its proximity to the halibut and salmon supply. Eight leading fisheries scientists will locate in Seattle, among them William S. Thompson, of the California state fisheries, and Dr. H. F. Rich, of Washington, D. C.

About a year ago a treaty was entered into by the United States and Canada looking to the conservation and control of the Halibut fisheries of the Pacific coast. The commission was organized early in the year 1925 and appointed a staff to take care of the scientific investigations. As the commission found it desirable to locate its scientific staff in Seattle, and wished to be within reach of the College of Fisheries library and laboratory facilities, the University of Washington offered to furnish quarters for them in one of the group of buildings housing the College of Fisheries.

A short time after this the various fish commissions of the states of Washington, Oregon, California, the territory of Alaska, Province of British Columbia and the Federal Fish Commissions of United States and Canada met in Seattle and organized a federation looking to better cooperation in working on the many salmon problems of the Pacific coast. Dr. H. F. Rich, of the U. S. Bureau of Fisheries, in conjunction with an executive committee, were selected to outline plans for standardizing and coordinating the work of the various commissions so far as possible. It was not the intention in the formation of this federation to have the research work done by other than the agencies heretofore operating. In other words, Canada, British Columbia and the other commissions function just the same as they always have done, the idea being merely to meet and exchange ideas looking to a more effective attack upon our salmon problems. For the same reasons as outlined above in connection with the International Fisheries Commission, Dr. Rich was also granted quarters in the same building.

Since then, at the request of the U. S. Bureau of Fisheries, the university has furnished quarters for those scientists of the bureau, who are working upon Pacific and Northwest problems and whose headquarters it has been found convenient to locate in Seattle.

JOHN N. COBB

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SCIENTIFIC BOOKS

Researches of the Department of Terrestrial Magnetism, Volume V.

THE Department of Terrestrial Magnetism of the Carnegie Institution of Washington, established in

1904 for research in terrestrial magnetism and allied phenomena, was faced at the outset with the lack of sufficient accurate data on which to base its researches. Various governments had done much in the way of operating magnetic observatories and conducting magnetic surveys in their respective territories, but there were many countries where the governments had not been able or willing to have the needed observations made and the data for the oceans were meager and unreliable.

Thanks to the energetic and efficient world magnetic survey operations of the Department of Terrestrial Magnetism, the needed data have now been supplied for practically all the land and water areas between latitude 60° north and 50° south. One of the immediate practical results of this work has been the furnishing of accurate information regarding the compass variation over the ocean areas, of great benefit to the navigator.

Volumes I, II and IV of the researches of the Department of Terrestrial Magnetism contained the results of observations made on land between 1905 and 1920 and Volume III was devoted to the results of observations at sea between 1907 and 1916. Volume V, recently issued, contains the results of magnetic and electric observations made aboard the *Carnegie* between 1915 and 1921 and reports of several special investigations. The cruises during that period covered over nine thousand two hundred miles and extended into the Atlantic, Pacific, Indian and Southern oceans. A cruise of special interest was the circumnavigation of the Antarctic Continent in 1915 and 1916. The tracks of previous cruises were crossed at many points, thus furnishing information regarding the change of the earth's magnetism with lapse of time. The ocean magnetic survey has now reached the point where this class of observations is the most important one and it is gratifying to know that there is prospect of the resumption of the operation of the *Carnegie* for that and other purposes in the near future.

With the accumulation of observations in terrestrial magnetism and atmospheric electricity, not only from the work of the Carnegie Institution, but from that of the various governments, it has been found possible to study the correlations of the various magnetic and atmospheric electric elements with each other and with solar and other phenomena. The correlations appear to be fundamental to adequate explanation of these observed phenomena.

Volume V contains also a discussion of navigation of aircraft by astronomical methods, which is one of the difficult problems, especially in the Arctic. It also contains a description of the compass varimeter, an instrument which fills a long-existing need for the investigation of local magnetic disturbances, hidden magnetic objects and materials and for registering intensity variations with accuracy under field conditions.

N. H. HECK

Sermons of a Chemist. By EDWIN E. SLOSSON, author of "Creative Chemistry," etc., director of Science Service, Washington, D. C. New York, Harcourt, Brace & Co.

DR. SLOSSON has been long known and honored as a clever, straightforward journalist, with a liking for accuracy, and the saving grace, where such is needed, of humor. He has been still longer if not better known as a chemist, and as interested in the human side of all problems he now comes before us as a preacher. For there are no facts in chemistry or anywhere else in the world that do not somehow have human bearings. It is not well to leave these all to the clergy, for even a truth must be seen from several different aspects, and new truths not yet moss-grown or even seasoned constantly sweep into our line of vision. It is no use for us to resist them. Whether we like them or not, if spurious they will soon fade away—if genuine they are here forever. If so it is well for us to know what they signify. And as a guide in this quest, we can ask nothing better than this whimsical, jovial, scholarly and sympathetic chemist.

This volume is made up of twenty-two discourses, actually delivered and all related on the one hand to science, on the other to the spiritual side of scientific knowledge. These range widely from "The Greatest Miracle of the Bible," the creation of man from the dust of the earth (that is from carbon, oxygen, hydrogen, nitrogen, lime and the rest of the ingredients, which pass into and through his body, never to stay) to the "Seven Sons of Satan," which torment and divert the even current of man's life.

The fine humor, overlying a ripe common sense, makes every chapter excellent and profitable reading. Often a new way of putting a new idea suddenly makes it self-evident. Thus:

> Science is based not on verified facts but on verifiable facts. If some antiquarian should unearth a death-bed confession of Joseph Priestley, stating that he had never discovered oxygen, and that his paper claiming that discovery was a hoax, most chemists would not care enough about it to read it. Priestley may have been a fraud for all we know, but oxygen is a reality, as we know.

I may quote a few more passages:

> Jehovah appears from the first as a decent God, although bloody, while Zeus had a past he could not live down. To ascribe wings to God was a primitive inspiration. To ascribe morals to God was not thought of for a thousand years later. . . . God is not affected by what we think of Him. He is not annihilated when we forget him.

> We all specialize in the virtues, devoting ourselves to such as suit our purposes. Some of us favor the lower end of the moral spectrum and display the red badge of courage. Others cultivate the more delicate vibrations of the blue end, purity, constancy and truth. Most of

us are prismatic and changeable, flashing forth one color and sometimes another, perhaps in the course of a lifetime displaying them all, but never all at once and equally in all directions.

The true object of education is the cultivation of the faculty of prevision. If you young people have been properly educated, you have had your heads turned. . . . Providence means seeing ahead. . . . You should be able to distinguish between a rising statesman and a false alarm.

Nations are always conquered from the inside. So long as we are normally strong, we shall be strong in every other way. . . . Those who perpetrate injustice, those who appeal to violence, those who stir up class hatred are the men whom we as a nation have to dread and against whom we have to protect ourselves. Liberty and independence, law and order, are not preserved by written constitutions and statutes, not by police and armies, not by wealth and success, but by the morality of the people. . . . Americanism is one of the fine arts, the finest of all the fine arts, the art of getting along peaceably with all kinds and conditions of men. We Americans have had more experience with the practice of this art than other nations, and it is not undue boasting to say that we have acquired a certain proficiency in it.

If all sermons were so graciously composed and so full of meat as those of Dr. Slosson, the churches would not worry over empty pews.

DAVID STARR JORDAN

STANFORD UNIVERSITY

SPECIAL ARTICLES

ASEXUAL REPRODUCTION WITHOUT LOSS OF VITALITY IN MALARIAL ORGANISMS

THE life-cycle of *Plasmodium praecox,* the protozoan parasite of bird malaria, is similar to that of the plasmodia of the human malarias. Asexual reproduction (schizogony) occurs in the vertebrate host, a bird, and sexual reproduction (sporogony) in the invertebrate host, a mosquito. The infective stages of the parasite, known as sporozoites, when inoculated by the mosquito into the blood of the bird, attack red blood corpuscles into which they penetrate. They grow within the corpuscles at the expense of the surrounding protoplasm until they almost completely fill them. Then the nucleus divides into from ten to twenty daughter nuclei, each of which, with a small amount of cytoplasm, is cut off as a minute merozoite. The average number of merozoites formed by each parasite is about fifteen (L. G. Taliaferro, 1925).[1] These merozoites escape into the blood stream when the corpuscle breaks down and some of them succeed in parasitizing new cells, thus starting another asexual cycle. Not all the merozoites undergo asexual reproduction; a few of them grow into sexual cells known as gametocytes. The gametocytes, however, do not pass through the stages of maturation, fertilization, etc., as long as they remain in the body of the bird; but if they are sucked into the stomach of the proper species of mosquito, they continue their development, and, after fertilization has taken place, produce by sporogony large numbers of sporozoites. Sexual reproduction thus takes place only in the mosquito and asexual reproduction only in the bird.

Bird malaria has been encountered in the common English sparrow on several occasions in this country; Whitmore in the month of August, 1913, secured parasites from a sparrow in New York which he inoculated successfully into canary birds. In 1918 I obtained infected birds from him and the strain has been maintained in canaries in my laboratory ever since. In 1924 Hartman obtained another strain from a sparrow in Baltimore; this strain has also been maintained since then in canaries.

The transfer of the infection from one bird to another is very simple. A small amount of blood from a vein in the wing or leg is sucked up into a syringe containing normal saline or sodium citrate solution and is then injected into the breast muscle or peritoneal cavity of a fresh bird; a few days later parasites can be found in the blood of the newly inoculated bird.

L. G. Taliaferro (1925)[1] has proved by plotting the mean size of parasites at frequent intervals that the asexual cycle of the strain of *Plasmodium praecox* from New York is thirty hours in length and of that from Baltimore twenty-four hours long. This periodicity occurs not only during the acute attack but also during the latent and relapse periods that usually follow. The normal course of an infection with bird malaria includes (1) a prepatent period between the time of inoculation and that of the appearance of parasites in the blood; (2) an acute period during which the parasite number increases very rapidly, finally reaching a peak, and then decreases until no parasites can be found in the blood by ordinary technical methods; (3) a latent period during which parasites are present in the blood but can be demonstrated only by prolonged and patient search; and (4) a period of relapse, either spontaneous or induced, when the parasites increase until they are again abundant in the blood. The period of relapse is followed by another latent period; and there may be several periods of latency and relapse.

[1] Taliaferro, L. G., 1925, "Infection and Resistance in Bird Malaria, with Special Reference to Periodicity and Rate of Reproduction of the Parasite," *Amer. Journ. Hyg.,* 5: 742–789.

Periodicity in bird malaria has been confirmed for the Baltimore strain by Drensky and Hegner (1926).[2] Whether or not the period of the asexual cycle of the New York strain has become longer during its extended cultivation in canaries without asexual reproduction is not known. If we accept thirty hours as the length of the asexual cycle of the New York strain we can easily compute the number of asexual generations this strain has passed through since it was obtained in 1913. This period consisted of slightly over twelve and one half years, or about 109,440 hours. Dividing this number by 30 gives 3,648, which is approximately the number of asexual generations this strain passed through during that period without the intervention of sexual reproduction.

If we accept twenty-four hours as the length of the asexual cycle in the Baltimore strain the data are as follows: total period, about one year and one half; number of days, about 550; number of asexual generations, about 550. Whitmore reported, in 1921,[3] that three of his canaries remained infected with the New York strain for twenty-nine months (until their death) after they were inoculated—a period during which about 700 asexual generations must have taken place in a single host. Mazza (1924)[4] records a bird that was still infective four years and two months after the original inoculation, but the number of asexual generations can not be computed in this case because the length of the asexual cycle is unknown for his strain.

The length of the asexual cycle is known for the organisms of human malaria; that of *Plasmodium vivax,* which causes tertian malaria, is forty-eight hours; that of *P. malariæ,* of quartan malaria, is seventy-two hours; and that of *P. falciparum,* of estivoautumnal malaria, is twenty-four to forty-eight hours. It seems certain that asexual reproduction continues at the same rate throughout human infections as it does in those of birds, hence the number of asexual generations may be calculated approximately by dividing the number of days of the infection by the length of the asexual cycle of the species concerned. It is of course necessary to prove that the infection measured is due to one group of parasites and not to sporozoites inoculated by mosquitoes subsequent to the original infection.

The rate of asexual reproduction is usually accepted by protozoologists as a measure of the vitality of a strain. This rate has been shown to be maintained by the Baltimore strain of *Plasmodium praecox* for over a year and there is every reason to believe that the rate will not decrease to any considerable extent in the future. Another criterion of vitality exists among parasitic protozoa and that is virulence. The evidence shows that both the New York and Baltimore strains have maintained their virulence throughout the entire period since they were secured. A factor of interest in regard to the rate of reproduction and virulence observed is the constant environment in which the malarial organisms live.

Does reorganization take place during asexual reproduction in *Plasmodium praecox?* This is a question that can not be answered. No such phenomenon is known, but this does not prove that a reorganization process is absent since we know very few of the cytological details of the malarial parasites during reproduction. We do know that a differentiation takes place in the blood, resulting in the production of sexual cells from the asexual generation, but as stated above these sexual cells do not continue development in the blood. Perhaps other changes corresponding to endomixis occur at some stage during the growth of the schizonts or when the merozoites are formed.

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[2] Drensky, Kosta, and Hegner, R. W., 1926, "Periodicity in Bird Malaria," *Amer. Journ. Hyg.,* 6: 312–314.

[3] Whitmore, E. R., 1921, "Observations on Bird Malaria and the Pathogenesis of Relapse in Human Malaria," Johns Hopkins Hosp. Bull., 29: 62–67.

[4] Mazza, S., 1924, "On the Duration of Relative Immunity in Malaria of Birds," *Journ. Trop. Med. and Hyg.,* 27: 98–99.

CERAMIC PIGMENTS OF THE INDIANS OF THE SOUTHWEST[1]

THE chemical nature of the coloring matter used by the ancients as ceramic pigments has been definitely established in a great many instances, but the small quantities available for analysis have frequently served as a barrier to their identification. As a matter of fact, the literature on this subject is very meager. The Encyclopaedia Britannica[2] states that all the black pigments ordinarily used contain carbon as the principal constituent. They are ivory black, lamp black, charcoal black, india ink and graphite (sometimes called black lead or plumbago). The same publication[3] in an article on Italian ceramics after the year 1200 A. D. states that black was made from a mixture of various colors. These included antimonate of lead for the yellow, ferric oxide for the red, copper oxide for the green, oxide of cobalt for the blue and manganese for the brownish purple.

Robbins, Harrington and Freire-Marreco[4] state that the modern Tewa Indians use a black paint for the decoration of pottery made from the Rocky Moun-

[1] From the Department of Chemistry, University of Colorado, Boulder, Colorado.

[2] Encyclopaedia Britannica, 21, 598 (1911).

[3] Encyclopaedia Britannica, 5, 737 (1911).

[4] "Ethnobotany of the Tewa Indians," Bureau of American Ethnology, Bulletin 55, 58 (1916).

tain bee plant or guaco (peritoma serrulatum). Wissler,[5] while speaking of the Indians of the Southwest, says, "Here we find the paints of both vegetable and mineral origin, the reds and yellows from iron, the blacks from the juices of plants. By proper firing, the desired colors could be made permanent." Wissler was here no doubt referring only to the Indians of to-day, although his statement has been interpreted as referring to the prehistoric Indians as well. Watson[6] has studied the modern art of the making of pottery of the Tewa Indians, and states that the black pigment is obtained by boiling down the juice of the bee plant until it becomes black and thick. After the dried unburned utensils have been decorated with this liquid, they are fired by placing them on stones in the middle of a bed of coals, piling flat pieces of manure around and over them, and leaving them there for about an hour. They are then polished by rubbing grease over them before they are cold. At the museum of the American Indian in New York there is on exhibit a long needle cactus. Near it is a tube containing a thick black liquid which is indicated as coming from it and as being used in decorating pottery by the Indians of the Southwest. The mode of preparation is no doubt the same as in the case of the paint of the bee plant. Various authorities have questioned the possibility of such organic coloring materials being used and withstanding the temperature of firing. However, such arguments could not be advanced in the case of the firing at such a low temperature as the Tewas of to-day use.

The fact that present-day Indians use a black of vegetable origin has apparently caused investigators to lose sight of the work of Nordenskjöld,[7] who made a rather extensive study of the pigments used by the cliff dwellers. A qualitative analysis led him to believe that the red pigment was the iron sesquioxide Fe_2O_3. He states that the red and yellow colors come from iron ochers prepared in stone mortars, the various shades being the result of various degrees of burning. Nordenskjöld found a large spherical vase at the Step House in the Mesa Verde whose decoration was so thick that he could scrape off enough for analysis. It was found to be an iron base and he concluded that it was probably the magnetic oxide Fe_3O_4. He also states that in one of the ruins he picked up a piece of wood several centimeters long, at the end of which there was still attached a reddish substance, which he analyzed. It was found to be a resin mixed with iron ocher. He thus explained that this resin reduced the red oxide to the black oxide.

[5] "The American Indian," Clark Wissler, 72 (1917).

[6] *Art and Archeology*, 9, 24 (1920).

[7] G. Nordenskjöld, "The Cliff Dwellers of the Mesa Verde," Stockholm, 1893.

Kidder and Guernsey[8] in their report on archeological explorations in northeastern Arizona state that the pigment is a clear dull black, with a slightly bluish or slaty cast. No analyses were made, but they assumed it was an iron product as determined by Nordenskjöld.

Several years ago Mr. Earl H. Morris, who was at that time curator of the Aztec Ruin National Monument, asked the author to determine the composition of the black pigment used by the Chaco and Mesa Verde Indians. For this work he furnished a box of potsherds which were in a very good state of preservation.

The best method of removing the thin layer of coloring matter was found to be by means of hydrofluoric acid. This loosened it to such an extent that it could be very easily washed off. Comparative analyses were made of both the pigment and the body of the pottery. Manganese, which might have been responsible for the color, was found to be lower in the pigment than in the clay. The most prominent element in the surface was iron. After considerable effort it was found possible to scale off thin flakes of the black pigment, which were magnetic and which became non-magnetic on heating in the oxidizing flame. Conversely, a potsherd covered with a bright red pigment, blackened on heating in the reducing flame, while becoming magnetic. One piece of red pottery was found blackened on the under side. It looked as if it had been smoked up over a fire, but this was not the case, as the black was magnetic. It was either the result of the reducing gases which were present at the bottom at the time of firing or at some later time while in use over an open fire.

One of the potsherds with a black design was fired in a furnace at about 1,000° C., with the result that the design became a dull red on a lighter background, showing that the original firing must have been at a comparatively low temperature.

It is therefore evident that the black pigment of the prehistoric Indians of the Southwest was the sesquioxide of iron, commonly known as magnetite, while the red pigment was the mineral hematite.

The use of the two oxides of iron for the production of black and red pigment, as well as the control of the processes of oxidation and reduction is to be regarded as a rather notable scientific achievement of the Indians.

It is also interesting to note that the use of hematite as the cheap barn paint of to-day must date back to very early times.

The author wishes to take this occasion to thank Mr. O. B. Muench for his assistance in making some

[8] Bulletin of the Bureau of American Ethnology, 65, 130 (1919).

of the analyses, and Dr. E. B. Renaud for some of the literature references.

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THE NATIONAL ACADEMY OF SCIENCES

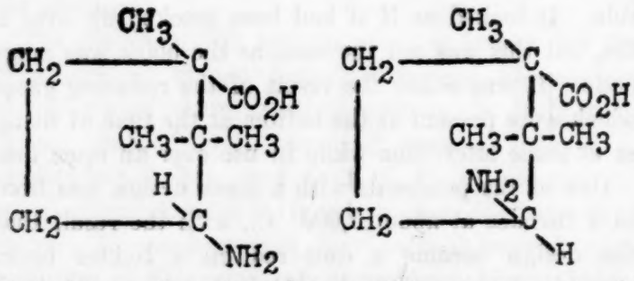
AT the annual meeting of the National Academy of Sciences held in Washington, on April 26, 27 and 28, the following papers were presented:

A crystalline-diazo compound of the camphor series: WILLIAM A. NOYES and FORREST E. KENDALL.

Chiles and Noyes (*J. Amer. Chem. Soc., 44,* 1798 (1922)) succeeded in preparing six optically active, aliphatic diazo compounds in which the only asymmetric carbon atom was that connected with the diazo group. Levene and Mikeska (*J. Biol. Chem., 55,* 595 (1923)) have also obtained optically active diazo compounds, though they failed to confirm some of the work of Noyes and Chiles.

The diazo compounds prepared were all liquids and had small rotatory power. It seems very desirable to prepare crystalline compounds, if possible, and also compounds giving a greater rotation.

It seemed possible to realize these conditions by the preparation of diazo compounds from *cis-* and *trans-*aminocamphonanic acids, which have the following configurations:



cis-Aminocamphonanic acid *trans*-Aminocamphonanic acid

The diazo compound of the methyl ester of the *cis* acid has been obtained by treating an etherial solution of the anhydride of the acid with sodium methylate, washing the solution of the diazo compound with water, freezing out the water at −80°, concentrating in a current of dry, carbon dioxide-free air at a low temperature and crystallizing from ether at −80°. So far as we have been able to learn, this is the first diazo compound having the group in the gamma position with reference to an ester group. The compound has a rotation of approximately 410.

To demonstrate the asymmetry of the diazo group in this compound it will be necessary to prepare the corresponding compound from the *trans* isomer. The work on this is not yet complete.

Atomic formation and disintegration, and separation of isotopes: PROFESSOR W. D. HARKINS.

The synthesis of 2-phenyl-benzoselenazole-4'-arsonic acid and of some other benzoselenazoles: PROFESSOR MARSTON TAYLOR BOGERT and ARTHUR STULL.

o-Chloronitrobenzene is converted into the o-nitrophenyl diselenide and the latter reduced to the zinc salt of o-aminophenyl selenophenol. By the action of aldehydes or acid halides upon this amino selenophenol, benzoselenazoles are obtained in excellent yield. When nitrobenzaldehydes or nitrobenzoyl chlorides are employed, 2-nitrophenyl-benzoselenazoles result, which can be readily reduced to the corresponding amino derivatives. Application of the Bart reaction to these amines gives the corresponding arsonic acids, the alkaline salts of which are freely soluble in water and are now being tested pharmacologically.

The products are therefore water-soluble organic arsenicals containing selenium as part of the molecule, and represent one phase of the exploratory work now being conducted at Columbia University to determine the therapeutic value of organic selenium derivatives as well as to gain additional knowledge concerning the chemistry of this group.

The alleged constancy of our physico-chemical constants; the metastability of naphthalene: ERNST COHEN, GEORGE HENRY BRANDES and JOHN CALVIN KELLER (by invitation).

New evidence in favor of a dual theory of metallic conduction: PROFESSOR EDWIN H. HALL.

Professor Bridgman has recently discovered a development of Peltier effect heat where an electric current changes direction within a metal crystal, and he has expressed the opinion that none of the well-known theories of electric conduction would lead us to expect such an effect. The dual theory, by means of a formula published several years ago, readily explains this phenomenon, as Professor Bridgman at once admitted when this formula was brought anew to his attention.

Professor Millikan has still more recently announced that, by experiments and reasoning of his own, he has been led to the conclusion that most of the electrons which maintain an electric current within a metal do not share the energy of thermal agitation, while the thermions, which he thinks responsible for thermoelectric action, do share this energy. This evidence appears to give strong support to conceptions which have long been held and repeatedly expressed in the development of the dual theory.

Applied to the results of Bridgman's experiments on the electrical and thermal behavior of metals under high pressure, the dual theory appears to be helpful in establishing a rational relation between the various effects observed.

Determination of excitation potentials of soft X-rays: K. T. COMPTON and C. H. THOMAS, Princeton University.

By soft X-rays we refer to radiation emitted from solids when bombarded by electrons whose energies correspond to a fall through potential differences from 5

to 2,000 volts and which may be expected to have wave lengths between 2,000 and 5A. This is the largest spectral region which is almost unexplored, but overlaps the extreme ultraviolet region at one end and the known X-ray region at the other. The non-penetrating and nearly non-reflecting character of this radiation has prevented its study by spectroscopic methods. It may be detected, however, by its photoelectric action in causing the emission of electrons from a neighboring electrode. If this photoelectric current is plotted as a function of the voltage at which the radiation is excited, there are discontinuities in the curve which probably are to be explained as minium voltages at which particular parts of the radiation can be excited. These critical voltages V lead to an estimate of the wave lengths of the radiation λ by the substitution in Einstein's photoelectric equation $V = \frac{300\ hc}{e\lambda} - \phi$, which has been verified for radiation of both longer and shorter wave length than that in this soft X-ray range. A method of spectroscopy in this region consists therefore in an accurate determination of the critical voltages V.

Unfortunately this determination is difficult. There are several causes of spurious discontinuities in the curves, leading to false values of V. Also these discontinuities are generally so slight as to escape detection or to be masked by the errors due to the limited accuracy of observations. Thus the only consistent agreement in previous work has been in connection with the few most prominent discontinuities.

We have made a study of the causes of spurious discontinuities and especially of methods for increasing the precision and sensitivity of this method. By special design to make the currents as large as possible, by unusual precautions to insure steadiness in the electrical circuits, by a balancing method of measuring galvanometer currents and by a new method of using an electrometer we have been able to measure the currents involved in the experiment accurately to 1 part in 10,000 and to secure absolute steadiness at this sensitivity. This has enabled us to plot the first or the second derivatives of the original curves, making calculations by a computing machine, and thus so to magnify discontinuities in the current-voltage curves as to make the method one of real precision.

By this method numerous elements of the soft X-ray spectrum have been discovered which were incapable of detection by the former methods. The soft X-ray spectra of Fe, Co, Ni, Cu, C and W are shown to be rich in lines and to raise interesting problems of interpretation and classification. Slides are shown to explain the method and illustrate the results.

Links connecting fluorescence and the luminescence of incandescent solids: PROFESSOR E. L. NICHOLS.

Various white and refractory solids—particularly oxides—at certain stages of incandescence have been shown to greatly exceed in brightness a black body of the same temperature and have therefore been described as *luminescent.*

In addition to the criteria justifying the term, which were noted at the time of the original experiments (1922), new facts connecting the phenomenon intimately with fluorescence have recently been discovered. These are:

(1) That traces of an activating element in solid solution in the incandescent material will enhance the brightness of luminescence many fold.

(2) That the luminescence of these activated solids occurs at a transformation temperature which is characteristic of the activator and independent of the solvent.

(3) The intimate relation between the emission spectrum of the incandescent body and the fluorescence spectrum of a solid containing the same activator.

Some thermionic experiments with a new source of positive ions: C. H. KUNSMAN (introduced by K. T. Compton).

Fused mixtures of very pure artificial magnetite and about 1 per cent. of an alkali or alkaline earth oxide furnish a very good source of positive ions when used as a hot anode in a vacuum. This source compares favorably with the present thermionic sources of electrons in ease of operation and control. The advantage of this source over that of a hot platinum strip is shown. The effect of reducing the mixture in hydrogen was to increase the positive emission about ten fold. Barton and Harnwell, of Princeton, have shown conclusively by a mass spectrograph analysis of this emission that the positive current consists only of singly charged particles of the alkali metal or alkaline earth metal which was introduced in the original mixture in the form of a salt.

Since, for a considerable range of temperature, this emission obeyed Richardson's equation, $I_+ = A\,T^{\frac{1}{2}}\,\epsilon^{-\phi e/kT}$, definite and reproducible values of φ_+, the equivalent work function in volts for the alkali or alkaline earth metal ions were obtained. The value of φ_+ for K ions vaporizing from an Fe–K mixture was 2.10 volts and for Cs ions vaporizing from an Fe, Al, Cs mixture was 2.37 volts. In the case of an Fe – Ba mixture, the Ba ion emission was quite constant at sufficiently high temperatures where appreciable electron currents were also obtained. φ_+ was 2.01 volts for Ba when φ_- for the reduced surface was 3.60 volts, where both ion and electron currents were measured for a given temperature throughout a range of from 1075 to 1300° Kelvin. The electron affinity, φ_-, of the surface is larger than φ_+, therefore the Ba atom is robbed of one of its outer electrons on vaporizing from the surface. However, φ_- is not large enough to remove both outer electrons, as no doubly charged Ba ions were observed in the mass spectrograph studies.

Capillary condensation and adsorption: PROFESSOR WILLIAM C. BRAY and HAL. D. DRAPER.

There are presented typical results of measurements of the sorption of water vapor at 25 per cent. on the partially hydrated oxides, copper oxide, manganese dioxide, and mixtures of these oxides, in the form of porous granules. In every case, 85–90 per cent. of the

sorption took place at pressures greater than half the vapor pressure of pure water. Other examples of this type of sorption isotherm are cited, and it is pointed out that earlier investigators have demonstrated that the sorption at the higher pressures is due to condensation of liquid in capillaries. In the case of copper oxide, the radii of the capillaries range from 15 Ångstrom units to about 150.

Evidence is presented that the true adsorption at lower pressures in an entirely different phenomenon from capillary condensation, and is a necessary precursor to it. The latter will occur only when the surface (covered with the adsorbed monomolecular layer) is sufficiently curved. It is suggested by J. W. McBain and the writers that, for materials which are highly adsorbent at low pressures such as charcoal or partially dehydrated hydroxides, the structure is a very open or incomplete lattice or lattices *into the spaces of which the individual adsorbed molecules penetrate.*

Changes in the rate of rotation of the earth and their geophysical consequences: PROFESSOR ERNEST W. BROWN.

The first part of this paper is a summary of our knowledge of the apparent deviations of the moon from its gravitational orbit, including in the latter the effects of tidal friction. The oscillatory and other characteristics of these deviations are again discussed. The second part is a similar discussion for the motion of the earth round the sun. In both cases an attempt is made to separate out the portions which are due to errors of observation. It is concluded that the remaining deviations give good evidence of the hypothesis originally made by Simon Newcomb when he discovered the lunar deviations, namely, that both sets of variations are due to variations in the rate of rotation of the earth. It is shown that the strongest part of this evidence has only been available within the past ten years.

Granting that the rate of rotation of the earth is variable it is next shown that the only hypothesis which can account for it with any semblance of probability is a variability in the earth's moment of inertia and that this must involve changes in the external radius. The extreme limits of these changes are 5 inches to 12 feet according to the hypothesis made as to the depth of the source from which the changes originate. The former corresponds to uniform changes of radius throughout the whole mass of the earth; the latter to forces at a depth of 50 miles which merely raise or lower the crust of the earth.

Geophysical evidences of such oscillations are next considered. The inequalities of the crust will necessarily require that seismic effects of all kinds appear. Some further evidence of a correlation between earthquake periodicities and the variation of the earth's rate of rotation is given, in addition to evidence of a similar character brought out by Professor H. H. Turner, of Oxford, some years ago. It is pointed out that many other geodynamical effects such as mountain building, the maintenance of isostasy, tidal waves, are much simplified by the hypothesis. These oscillations taking place in periods of the order of a few years to a century or two are compared with oscillations taking place in geological periods hypothecated by Professor Joly a short time ago. The latter assumed them as the supposed thermal effects of radium in the interior of the earth. No hypothesis as to the chemical or physical cause of the short period oscillation, deduced by astronomical and mechanical arguments in the present paper, is put forward.

The elasticity of dunite and its bearing on the composition of the earth: L. H. ADAMS and R. E. GIBSON (introduced by Arthur L. Day).

The significance of volcanic gases found in hot springs: DR. ARTHUR L. DAY (illustrated).

The Californian Orogenic Period: PROFESSOR BAILEY WILLIS.

The central fact of the Californian orogenic period is the great batholith of the Sierra. Its known superficial area is 25,000 square miles, its probable area is three times that figure, and its volume presumably several hundred thousand cubic miles. The rock, so far exposed, is granodiorite with some more acid facies. Although large, this mass is not the largest among similar batholiths, it being exceeded by that of Lower California and that of British Columbia. The date of intrusion of the batholith in California was Upper Jurassic. The epoch of the gestation of the magma preceded that time. The effects as manifested in the uplift of successive mountain masses extend down to the present and have not yet come to an end. The Californian orogenic period thus covers geologic time since the Triassic.

The existence of the batholith raises a number of questions: what was its origin and manner of intrusion; what have been the mechanical effects of the presence of so large and so rigid a mass in the outer earth's crust upon the character of the deformation which the latter could undergo; what metamorphic changes might develop in the deeper portions of the batholith and what would be their effect in developing compressive stresses; what relation would such effects have to the great difference of elevation which actually exists between the Pacific deep and the Sierra summits; what force may be inferred to have acted to produce the orogenic developments and what variations of conditions may be postulated to account for their mode of action in this particular case.

The paper presented alternative answers to some of these problems and pointed out the direction of a reasonable hypothesis.

Studies of Pleistocene phenomena of Ohio River basin: FRANK LEVERETT (introduced by T. C. Chamberlin).

Studies in Ohio and West Virginia in 1925, toward which a grant of $500 was made from the Joseph Henry Fund, are a continuation of studies begun in 1924 in Indiana and Kentucky, which have for their main object the clearing up of the early Pleistocene history of the district tributary to Ohio River. This involves not only a mapping of the extent of each of the drift sheets, but

also the determination of the extent to which a ponding of water outside the ice border was produced, and the effect of such ponding in developing the present system of drainage, which is widely different from the preglacial drainage. Attention was also given to the amount of work done by the Ohio and some of its tributaries since each of the glacial stages. This throws light upon the relative dates of the different glacial stages. The studies in 1925 have shown that it was at the earliest stage of glaciation, known as the Jerseyan, that the main filling of the old north flowing drainage lines took place, the clay deposits in some of them being more than 100 feet thick. Since that time the streams have removed much of this clay, and have cut down 150 to 200 feet or more into the underlying rock formations. Much of this excavation was over with by the time of the third or Illinoian glacial stage, but the part of the Ohio above Wheeling seems not to have been fully excavated at that time. It reached its full depth, however, before the last or Wisconsin stage of glaciation.

It was probably at the Jerseyan stage that the ice-sheet reached its greatest extent in the Ohio drainage basin, though its limits were not greatly different from those of the third, or Illinoian, drift, and the general direction of ice movement seems to have been about the same in both stages, a southwestward movement from the Labrador peninsula. The drift of the second, or Kansan, glacial stage may be represented in the old drift of northwestern Pennsylvania, and in copper, and copper bearing rocks, brought into Ohio and Indiana by a southward ice movement from the Superior basin, which is out of harmony with the Jerseyan and the Illinoian ice movements.

Two new faunas in the marine Upper Triassic of Nevada: TIMOTHY W. STANTON (introduced by David White).

In the Triassic of the Tonopah and Hawthorne quadranges, Nevada, two faunas of Noric age have recently been discovered, both of which are later than the *Tropites subbullatus* fauna. The older of these consists chiefly of pelecypods, especially *Myophoria, Ostrea* and *Pinnigena,* and the other contains many ammonoids, including *Cladiscites* aff. *tornatus, Rhabdoceras* and *Rhacophyllites.*

Relations of European and American lower Paleozoic systems (illustrated): E. O. ULRICH.

Criteria in stratigraphic correlation: E. O. ULRICH.

Some phases of evolution in microfossils: R. S. BASSLER (introduced by E. O. Ulrich).

Some features of the structure of southeastern Idaho (illustrated): G. R. MANSFIELD (introduced by David White).

Physical and biological effects of high-frequency sound-waves in water: PROFESSOR R. A. WOOD and ALFRED L. LOOMIS.

High-frequency sound waves, of periods from 100,000 to 400,000 generated by a piezo-electric plate of quartz excited at 60,000 volts by an electrical oscillator of 2,000 watts output. The wave-length in water varies from a centimeter to a few millimeters, and small fish, worms and paramecia are killed in less than a minute by the sound-waves. If the beam of sound is directed towards the surface of the water, the surface is heaped up in a mound. The vibrations heat the water, a rise of 5° C. in one minute having been recorded.

Objectives of a fundamental study of Middle American civilization (illustrated): JOHN C. MERRIAM and SYLVANUS G. MORLEY.

The structure of living cells (film by Heinz Rosenberger): ALEXIS CARREL and ALBERT H. EBELING (introduced by Victor C. Vaughan).

The interpretation of the Michelson-Morley experiment in the light of the observations of the years 1925 and 1926: DAYTON C. MILLER, Case School of Applied Science, Cleveland, Ohio.

A complete study of the ether-drift experiments for 1925 and 1926 leads to the conclusion that there is a systematic displacement of the interference fringes of the interferometer corresponding to a constant relative motion of the earth and the ether of ten kilometers per second; and that the variations in the direction and magnitude of the indicated motion are exactly such as would be produced by a constant motion of the solar system in space, with a velocity of 200 kilometers, or more, per second, towards an apex in the constellation DRACO, near the pole of the ecliptic, which has a right ascension of 262° and a declination of +65°. In order to account for these effects as the result of an ether drift, it seems necessary to assume that, in effect, the earth drags the ether so that the apparent relative motion at the point of observation is reduced from two hundred, or more, to ten kilometers per second, and further that this drag also displaces the apparent azimuth of the motion about 45° to the west of north.

A recalculation of the earlier experiments by Michelson and Morley in 1887, and by Morley and Miller in 1904, has been made showing that they are entirely consistent with the present result. The question then arises, "Why is the magnitude of the effect less than would be expected on the stagnant ether and why is the direction of the effect at Mount Wilson deflected to the westward?" It seems necessary to reconsider the Stokes theory of the ether or the Lorentz-FitzGerald theory of contraction.

The present state of the problem of stellar evolution: PROFESSOR HENRY NORRIS RUSSELL.

Recent advances in atomic physics have led to a great increase in our understanding of internal conditions in the stars. We now know that, inside a star, the atoms have their outer parts knocked off, but retain their individuality, and it is possible to calculate at what rate heat should escape from the interior to the surface, and,

therefore, how bright the stars should be, if we know how large and massive a star is and how much denser it is in the interior than at the surface. It is well known that stars of the same mass are all about equally bright, no matter of what size they may be. It may be shown that this is a necessary consequence of the known general laws of ionization and opacity—considerable difference in the distribution of internal density affecting very little the amount of heat which escapes from the surface. The outstanding problem is to find where the heat radiated by the stars comes from, and in what manner it is liberated inside them. The existing evidence indicates that the heat is probably produced by a slow transformation of matter into energy after the manner first suggested by Einstein. The laws governing this process can at present be investigated only by a study of the stars themselves. It can be shown that, if all the stars were of exactly the same composition, stars of the same mass would be not merely similar in brightness, but also similar in size, color and temperature. This is not the fact, and it follows that some stars must contain more than others of the "active material," which is the source of heat.

It appears that the observed facts can be accounted for by assuming that there are two kinds of active material, both of which are transformed more rapidly the higher the temperature. For the first, the rate of transformation is nearly the same at all pressures. For the second, low pressure, as well as high temperature, favors the production of heat.

It can be shown that a star of given mass will automatically adjust its diameter and internal temperature until the rate of production of heat from one or other of these active substances is just sufficient to balance the radiation from the surface. If a large number of stars of different masses should come into existence in any manner, they would adjust themselves, probably within a few millions of years, so as to exhibit just such relations between mass, brightness and color, as are actually found in star clusters and among double stars. It is therefore no longer necessary to assume that different stars in the same cluster are of very different ages, as had to be done on the earlier theories.

What the life-history of a star would be depends upon the proportion of active material in its composition. If, as seems probable on the whole, this originally forms the larger part of the star's mass, a star of large mass will start as a red giant, gradually become hotter and whiter, and finally cool down and end as a faint dwarf star. Stars of smaller mass may begin their careers as dwarf stars without ever passing through the giant stage. White dwarf stars, like the companion of Sirius, may be accounted for as cases in which one of the two kinds of active material has been completely used up; and stars of all known types appear to find a place in the scheme. These conclusions differ from those reached recently by Dr. Jeans. The writer believes that certain of Dr. Jeans's conclusions, while mathematically sound, on the assumptions which he has made, do not correspond with the conditions that are actually met with in the stars.

Barro Colorado Island as a station for the study of tropical life (illustrated): FRANK M. CHAPMAN.

On painting eclipses and lunar landscapes (illustrated): HOWARD RUSSELL BUTLER (introduced by H. N. Russell).

Designs of a building devoted to general education in astronomy and related sciences (illustrated): HOWARD RUSSELL BUTLER (introduced by Henry Fairfield Osborn).

Orbit of a minor planet (100) Hekate: A. O. LEUSCHNER and H. THIELE.

The discovery of eclipsing stars: PROFESSOR JOEL STEBBINS.

Observations with the spectroscope reveal motions of certain stars which can be explained by their having large companions or planets. The periods of revolution of many of these attendant bodies are very short, even as small as one or two days. By choosing the proper time for light measurements, it is found that among the cases known in advance to be favorable fully one half of these double systems present eclipses as viewed from the earth. A study of the variation of the light of a star during an eclipse makes it possible to calculate the diameter of both the bright star and its dark or faint companion. As an illustration, it is noted that two stars moving in space parallel to the stars of the Big Dipper, and presumably belonging to that system, have each been found to have satellites. It is shown that each of the bright bodies is twice as heavy and gives one hundred times as much light as the sun, so that the latter would make only a mediocre planet for any star of the Big Dipper.

These observations are taken with the photo-electric cell, the same instrument that is used for transmission of pictures over telephone wires. The observer measures the light of stars by timing their effect on a delicate electrometer, attached at the eye-end of the telescope, and it is literally true that it is possible to measure and weigh a star by means of a stop-watch.

On the frequency of parallel proper motions among the stars: PROFESSOR FRANK SCHLESINGER.

Yale Observatory has recently issued a catalogue of the positions and proper motions of more than 8,000 faint stars between declinations 50° and 55° north. A discussion of these proper motions reveals many cases of stars separated by several degrees of arc whose proper motions across the sky are sensibly parallel and equal in amount. To make certain in any particular pair or group of cases that the motions are parallel in space, we should have to know the radial velocities, and these in general are not at present forthcoming. But the frequency with which the proper motions come out the same is much greater than can be due to chance and indicates that most of these cases represent true equality and parallelism of motion. If this view is correct it implies that star streaming is a common phenomenon.

(To be concluded)